(12) UK Patent Application (19) GB (11) 2 337 477 (13) A

(43) Date of A Publication 24.11.1999

(21) Application No 9811161.0

(22) Date of Filing 22.05.1998

(51) INT CL[6]
C21D 7/10

(52) UK CL (Edition Q)
B3N N6
B3A A137
B3V V2C

(56) Documents Cited
GB 0785534 A GB 0557960 A

(58) Field of Search
UK CL (Edition P) B3A , B3N , B3V
INT CL[6] C21D

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(54) Abstract Title
Manufacturing a screw connection and apparatus therefore

(57) Steel bars 1 used in the construction industry for reinforcing concrete are connected together using screw connectors 2. Prior to forming screw threads 3 on the ends 5 of the bars 1, the ends 5 are cold-forged to increase their tensile strength. The cold-forging is performed by an apparatus having four jaws in the form of rotatable plates with indenting portions, which squeeze the ends of the bars 1.

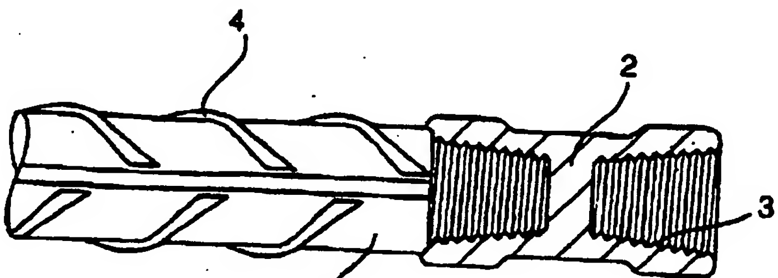

FIG. 1

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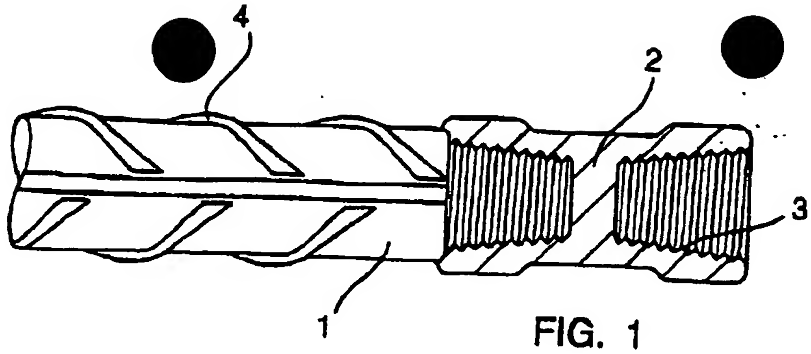

FIG. 1

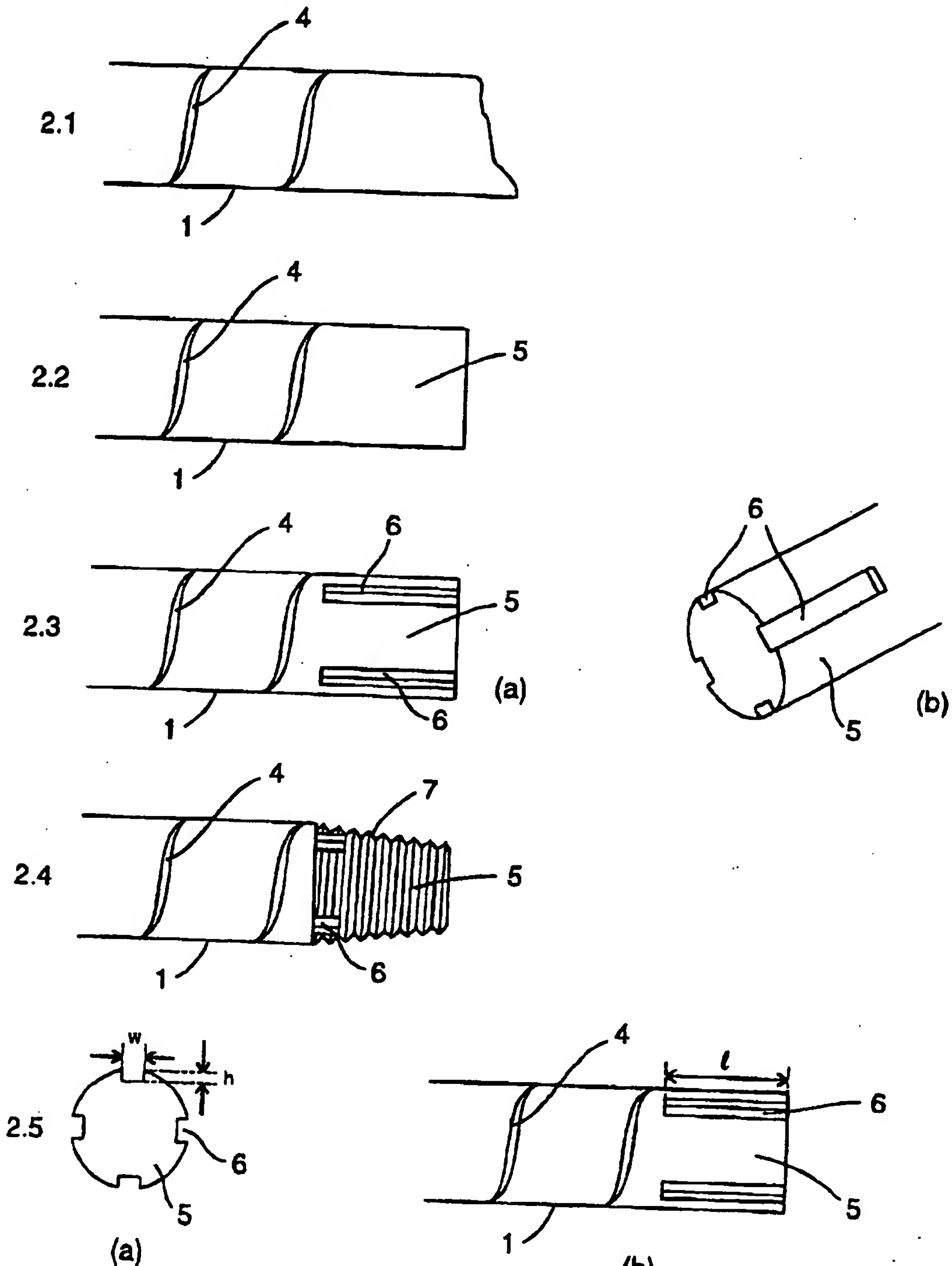

FIG. 2

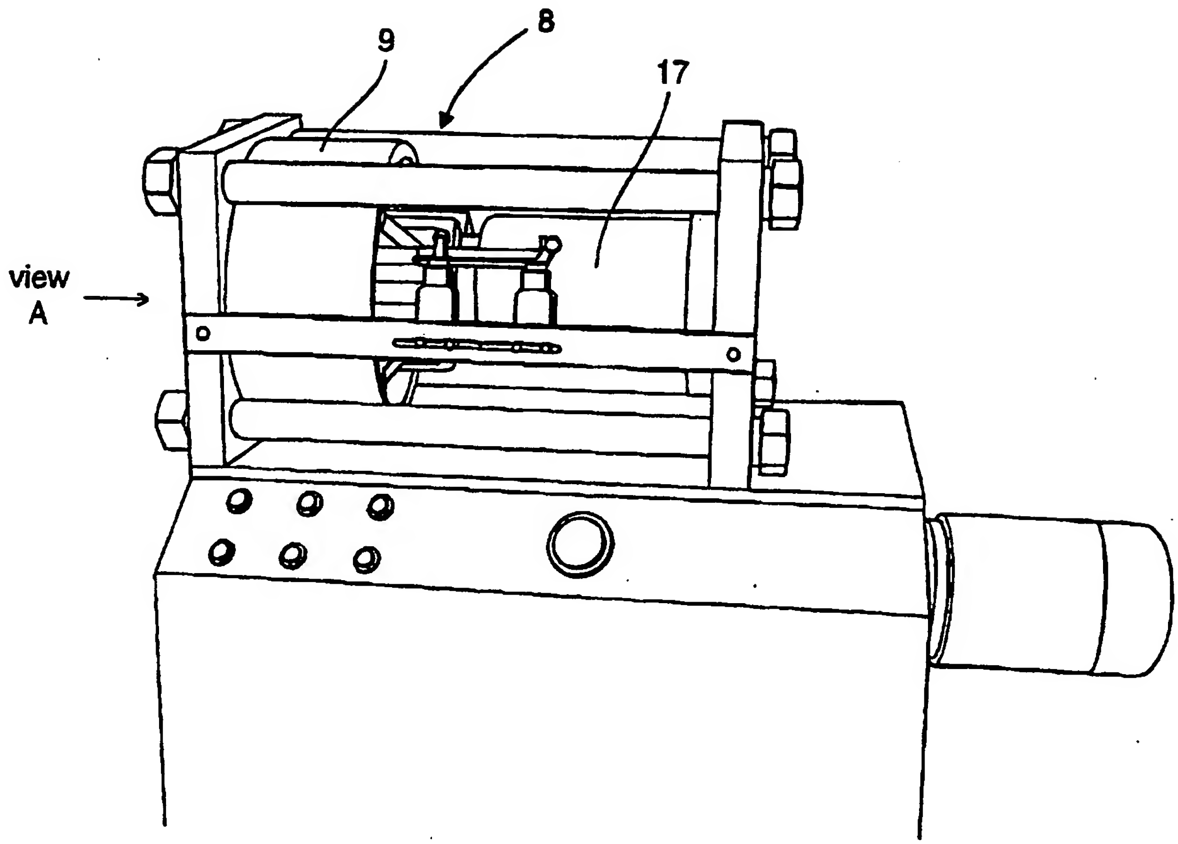

FIG. 3

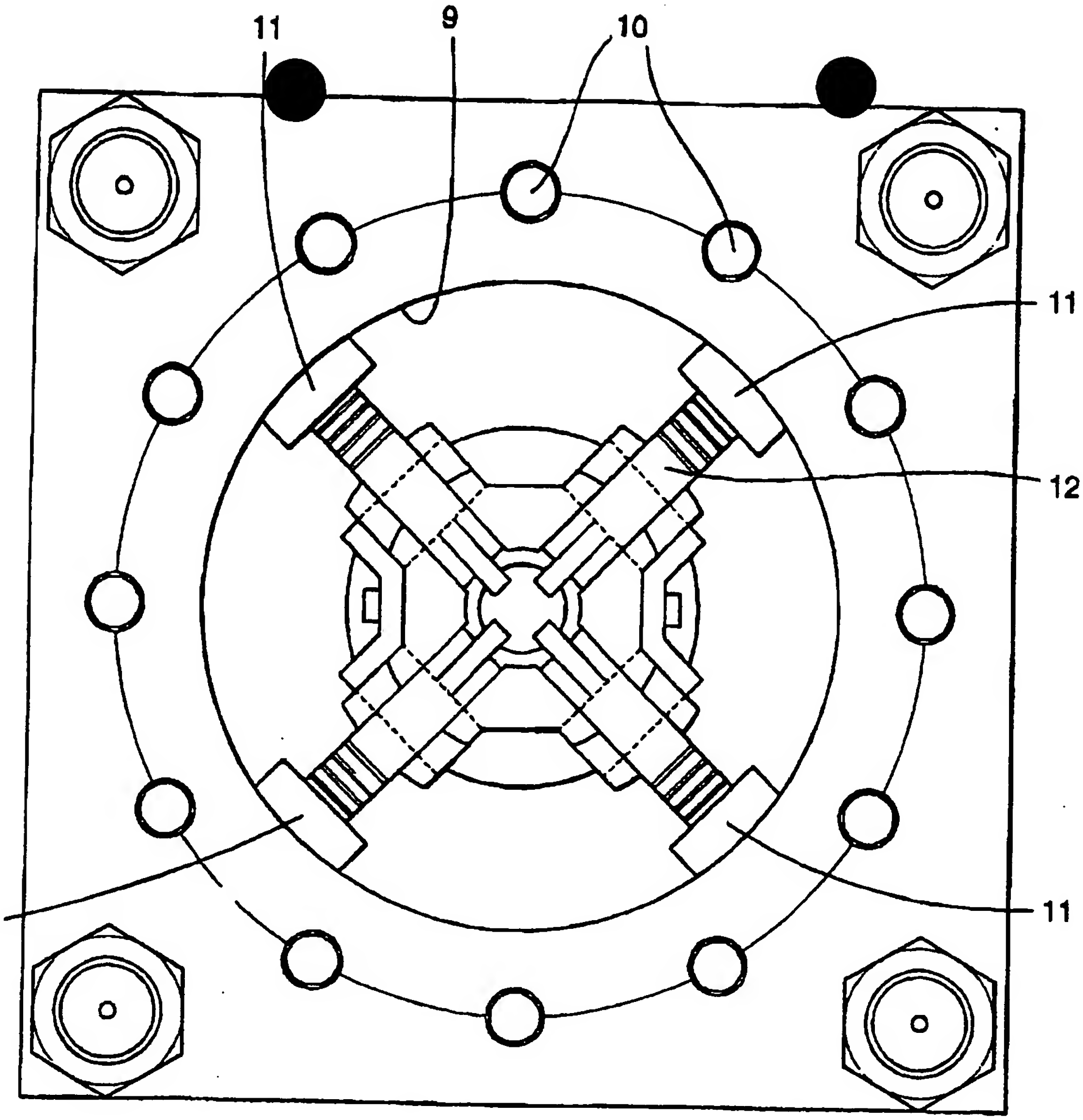

FIG. 4
(view A)

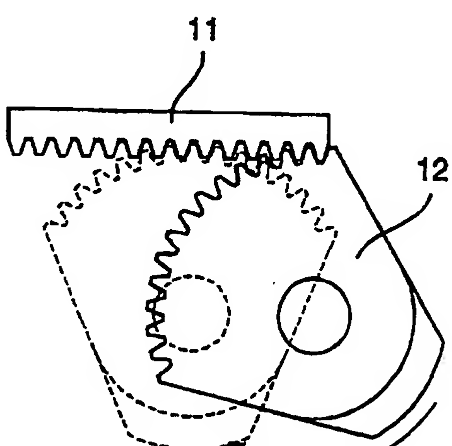

FIG 4a

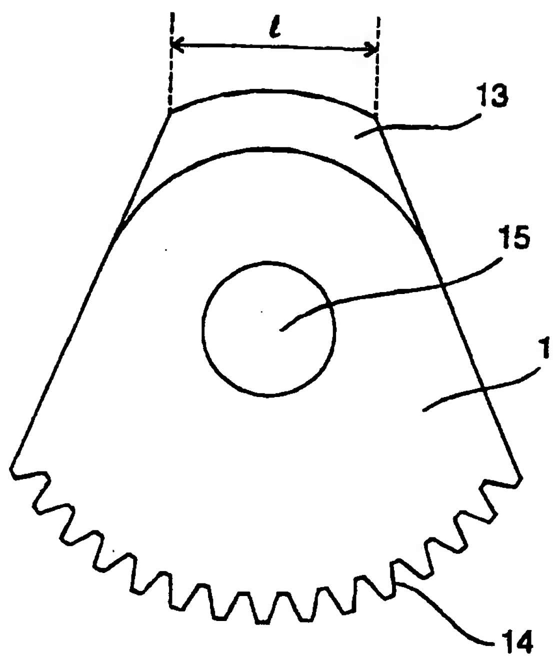

FIG. 5a

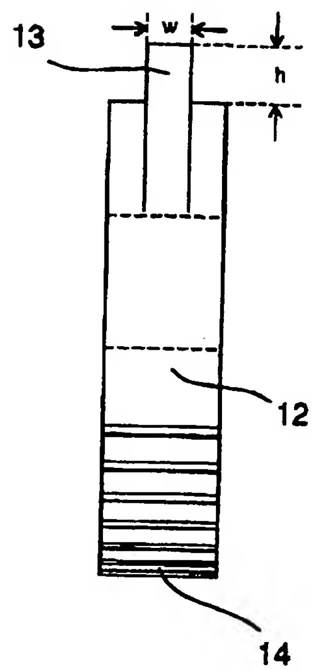

FIG. 5b

Method of Manufacturing a Connection and Apparatus Therefor

The present invention relates to a method of manufacturing a connection and apparatus therefor. In particular, but not exclusively, the present invention is concerned with a connection for joining lengths of reinforcing steel which may be used, for example, in the reinforcement of concrete.

Bars of reinforcing steel are manufactured in lengths which allow easy transportation of the material to a construction site. Often it is necessary to join two or more of these lengths together. One way of doing this is to use connectors which have threaded sockets at each end and which screw onto and connect the ends of the bars. The threads of the connector may be directed in opposite directions and the ends of the bars and the sides of the sockets may be tapered so that the two bars can be connected quickly and easily.

Although this type of connection is satisfactory, improvements to this coupling system would be desirable. For example, it has been found that this connection normally poses a weak point in the reinforcing steel structure.

Thus, according to a first aspect, the present invention provides a method of connecting two metal bars using a threaded connector, comprising the steps of:

a) increasing the tensile strength of the ends of the bars which are to be connected;

b) forming a thread on each of said ends; and

c) screwing the connector onto said ends to join the two metal bars.

Preferably the increase in tensile strength is a result of cold-working the ends of the bars, preferably by cold-forging. In one embodiment the end of the bar is squeezed by a plurality of jaws to deform the

material plastically and cold work it, thereby increasing the tensile strength of the material in this region. The end of the bar may then be threaded for engagement with the connector. The cold-forging is sufficient to increase the tensile strength of the metal bar in the region where the thread will be formed, but not to distort the overall dimensions of the end of the bar unduly. In this way, conventional tooling may be used to form the screw threads and conventional connectors may be used to connect the bars together.

In one preferred embodiment, jaws used to squeeze the end of the bar comprise rotatable plates which have a portion arranged to indent the bar.

Thus, when viewed from a second aspect, the present invention provides an apparatus for cold-working a workpiece, comprising a plurality of jaws arranged about a central axis to squeeze and indent a workpiece positioned on that axis, wherein the jaws comprise rotatable plates which have a portion arranged to indent the workpiece upon rotation of said plate.

Preferably the indenting portions comprise teeth which are configured to form grooves in the workpiece, preferably as longitudinal grooves. In the most preferred embodiment, the plates are mounted so that the plane of the plate includes the central axis along which the workpiece is positioned. The plates are preferably approximately segment shaped and have a set of cog-like teeth provided on their outer circumferential surface. The teeth of each plate engage a rack which is mounted to the inner surface of a housing such that the rack faces toward the central axis and extends parallel to it. In this way, when an assembly holding the plates is moved within the housing along the central axis and relative to the racks, the plates are rotated to drive the indenting portions of the jaws simultaneously into the workpiece.

In an alternative embodiment, the assembly holding

the plates may remain stationary and the housing of the apparatus may be moved relative to it.

Other arrangements for rotating the plates are also envisaged. For example, gear wheels could be used to drive the circumferential edge of the plates or the plates could be driven by hydraulic levers. However, such arrangements may make the apparatus more complex and therefore more expensive and more prone to failure.

Preferably there are more than two jaws so that a greater circumferential area of the workpiece is cold worked in a given operation. In the most preferred embodiment there are four jaws spaced equally about the central axis, as this provides a good compromise of area worked to the cost and complexity of the tooling. However, arrangements of three, five, six or more jaws may be more suitable for certain sizes of workpiece and for certain materials depending on their cold-working properties.

The term "bar" used herein is intended to include smaller stock material such as rods.

It is also envisaged that cold-forging the end of a member, such as a bar, prior to forming a thread may have application in other areas where precise dimensions are not absolutely critical.

Thus, when viewed from a third aspect, the present invention provides a method of forming a thread on an end of a member comprising the steps of:

a) cold-forging the end of the member; and

b) forming a thread on said end of the member.

Certain preferred embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 is a side elevation of one end of a reinforcing steel bar and a connector (the connector is shown in section);

Figures 2.1 to 2.4 show the bar during the steps of

manufacturing the thread and Figures 2.5(a) and 2.5(b) show a cold-forged bar from the end and side respectively;

Figure 3 is a view of the front of the preferred apparatus;

Figure 4 is a view of the side of the preferred apparatus in the direction of View A in Figure 3;

Figure 4a is a view of part of the apparatus;

Figure 5a is a view of a squeezing plate from the preferred apparatus; and

Figure 5b illustrates those parts of the indenting portion which govern the length, width and depth of the grooves.

As shown in Figure 1, lengths of reinforcing steel bar 1 may be joined together using a connector 2. in cross-section, the connector 2 is approximately H-shaped and comprises two tapered threaded sockets 3, as is conventional. The bar 1 may include webs 4 to aid keying to concrete.

Prior to fitting the connector 2 to the end 5 of the bar 1, the steps of Figures 2.1 to 2.4 are carried out. These steps are as follows:

The raw reinforcing steel bar 1 shown in Figure 2.1 is cut square to the desired length as shown in Figure 2.2. The end 5 of the bar 1 is then cold-forged (to be described in more detail below) to produce longitudinal grooves 6, as shown from the side in Figure 2.3(a) and as a perspective view in Figure 2.3(b). The cold-forging increases the tensile strength of the bar 1 in this end region 5 so that it is greater than the parent material. A screw thread 7 is then formed in the region which has been cold-forged, as shown in Figure 2.4.

Figure 2.5(a) and 2.5(b) show views from the end and the side of the cold-forged bar respectively. The dimensions of the grooves 6 shown in the figures are preferably as follows for the following sizes of bar:

Table 1

Diameter of the steel bar (mm)	12	16	20	25	32	40	50
Dimension of the groove							
width (mm)	3(±2)	3(±2)	3(±2)	5(±2)	7(±2)	9(±2)	12(±2)
length (mm)	18 (±4)	22 (±4)	26 (±4)	33 (±4)	45 (±4)	55 (±5)	65 (±5)
indent (mm)	2(±1)	2(±1)	2(±1)	3(±2)	3(±2)	3(±2)	4(±2)

As can be seen from the results of this table, preferably the bars 1 are squeezed to form grooves 6 which are of a depth of between 5-30% of the diameter of the steel bar 1, more preferably between 7.5-20%.

The front of a preferred apparatus for forming the grooves 6 is shown in Figure 3. The apparatus comprises a cage 8, the inside of which is shown enlarged and viewed from View A in Figure 4. The cage 8 houses a cylindrical sleeve 9 which is retained in place by bolts 10. Inside the sleeve 9 are mounted four equally spaced racks 11, which extend parallel to the central axis of the sleeve 9, and associated squeezing plates 12. The racks 11 engage the squeezing plates 12 as shown in Figure 4a.

Figures 5a to 5c show one of the four squeezing plates 12. As shown, these are approximately segment shaped and have an indenting portion 13 arranged on one end and a set of cog-like teeth 14 arranged on the opposite, circumferential edge. The teeth 14 are configured to engage those of the racks 11. Between the indenting portion 13 and the teeth 14 is provided a cylindrical hole 15 for a mounting spindle (not shown). The width (w), length (l) and height (h) of the

indenting portion governs the corresponding dimensions of the grooves 6. Different sized plates 12 are used for different sizes of bar 1.

As shown in Figure 4, the four squeezing plates 12 are arranged, equally spaced, at 90° to each other, within the sleeve 9 and with at least one of their teeth 14 in contact with a respective rack 11. The plates 12 are mounted to an assembly 16 on spindles which allow the plates 12 to rotate with respect to the assembly 16.

The assembly 16 is mounted to a hydraulic piston 17, which can be seen in Figure 3. The piston 17 drives the assembly 16 along the central axis within the sleeve 9. In so doing, the squeezing plates 12 are caused to rotate as they are moved relative to the racks 11, rotating the indenting portions 13 inwardly toward the central axis and into the end 5 of a bar 1 positioned along that central axis. The piston is then retracted to allow the bar 1 to be withdrawn.

The bar 1 would be inserted into and removed from the jaws of the apparatus in the direction of View A (Figure 4). A stop may be included to limit the insertion of the bar 1 and correctly position the grooves 6 at the end 5 of the bar 1.

Tables 2 to 6 show extracts from test reports, which report the results of tensile tests on certain preferred couplings.

Table 2

Job: Control Test

Coupler: Length: 55mm

Parent bar: Diameter: 16mm, Grade: 460, Pattern Code: SAF1, Complied with CS2: 1990

Test results:

Sample Mark	*Slippage (mm)	Ultimate tensile load (kN)	Condition of failure	Remark
1	0.05	115.0	FR	Test results comply with the requirements: (a) The tensile strength shall not be less than the specified requirements for the parent bar (b) The slip between the reinforcement connector and the parent bars shall not exceed 0.2mm in 2 minutes at the specified characteristic strength

Remarks: Load at specified characteristic strength: 92.5 kN

*Slippage - slip between the coupler and the parent bar in two minutes at the specified characteristic strength

Nominal ultimate tensile load 101.7 kN

SL - Slippage between coupler and parent bar

FR - Fracture in parent bar

Hong Kong Government General Specification for Civil Engineering Works, volume 2, 1992 Edition, Clause 15.33 referred.

Table 3

Job: Submission Test (to BS 8110:Part 1:1985)

Coupler: Length: 80mm

Parent bar: Diameter: 20mm, Grade: 460, Pattern Code: SAF1, Complied with CS2

Test results:

Specimen Mark	*Permanent Elongation (mm)	Ultimate tensile load (kN)	Condition of failure	Remark
1 2 3	0.04 0.05 0.07	190.0 197.5 199.0	FR FR FR	Test results comply with the requirements: (a) The tensile strength shall not be less than the specified requirements for the parent bar (b) The permanent elongation after loading to 60% of the specified characteristic strength should not exceed 0.1mm.

Remarks:

1. Load at 60% specified characteristic strength: 86.7 kN
2. Specified requirement for the ultimate tensile load of the parent bar: 159.0kN
3. *Permanent elongation - permanent elongation after loading to 60% of the specified characteristic strength.
4. SL - Slippage
   FR - Fracture in parent bar

Table 4

Job: Submission Test

Coupler: Length: 100mm

Parent bar: Diameter: 25mm, Grade: 460, Pattern Code: SAF1, Complied with CS2: 1990

Test results:

Specimen Mark	*Permanent Elongation (mm)	Ultimate tensile load (kN)	Condition of failure	Remark
1 2 3	0.05 0.07 0.06	312.0 316.0 308.0	FR FR FR	Test results comply with the requirements: (a) The tensile strength shall not be less than the specified requirements for the parent bar (b) The permanent elongation after loading to 60% of the specified characteristic strength should not exceed 0.1mm.

Remarks:

1. Load at 60% specified characteristic strength: 135.5kN
2. Specified requirement for the ultimate tensile load of the parent bar: 248.4kN
3. *Permanent elongation - permanent elongation after loading to 60% of the specified characteristic strength.
4. SL - Slippage between coupler and parent bar
   FR - Fracture in parent bar

Table 5

Job: Control Test

Coupler: Length: 120mm

Parent bar: Diameter: 32mm, Grade: 460, Pattern Code: SAF1, Complied with CS2: 1990

Test results:

Sample Mark	*Slippage (mm)	Ultimate tensile load (kN)	Condition of failure	Remark
1	0.07	495	FR	Test results comply with the requirements: (a) The tensile strength shall not be less than the specified requirements for the parent bar (b) The slip between the reinforcement connector and the parent bars shall not exceed 0.2mm in 2 minutes at the specified characteristic strength

Remarks: Load at specified characteristic strength: 369.9kN

*Slippage - slip between the coupler and the parent bar in two minutes at the specified characteristic strength

Nominal ultimate tensile load 406.9kN

SL - Slippage between coupler and parent bar

FR - Fracture in parent bar

Hong Kong Government General Specification for Civil Engineering Works, volume 2, 1992 Edition, Clause 15.33 referred.

Table 6

Job: Control Test

Sample details supplied by client as follows:

Coupler: Length: 145mm

Parent bar: Diameter: 40mm, Grade: 460, Pattern Code: SAF1, Complied with CS2: 1990

Test results:

Sample Mark	*Slippage (mm)	Ultimate tensile load (kN)	Condition of failure	Remark
1	0.07	790	FR	Test results comply with the requirements: (a) The tensile strength shall not be less than the specified requirements for the parent bar (b) The slip between the reinforcement connector and the parent bars shall not exceed 0.2mm in 2 minutes at the specified characteristic strength

Remarks: Load at specified characteristic strength: 578.0kN

*Slippage - slip between the coupler and the parent bar in two minutes at the specified characteristic strength

Nominal ultimate tensile load 635.8kN

SL - Slippage between coupler and parent bar

FR - Fracture in parent bar

Hong Kong Government General Specification for Civil Engineering Works, volume 2, 1992 Edition, Clause 15.33 referred.

Thus, there has been shown a new method of forming a connection, which advantageously has improved tensile strength and is quick and easy to produce. The preferred cold-forging apparatus is mechanically simple and can cater easily for a variety of different sizes of reinforcing steel bar.

Claims

1. A method of connecting two metal bars using a threaded connector, comprising the steps of:

a) increasing the tensile strength of the ends of the bars which are to be connected;

b) forming a thread on each of said ends; and

c) screwing the connector onto said ends to join the two metal bars.

2. A method as claimed in claim 1, wherein the increase in tensile strength is a result of cold-working said ends of the bars.

3. A method as claimed in claim 2, wherein said ends of the bars are cold-worked by a cold-forging operation.

4. A method as claimed in claim 3, wherein said ends of the bars are squeezed and deformed plastically by a plurality of jaws during the cold-forging operation.

5. A method as claimed in claim 4, wherein said ends of the bars are squeezed by four jaws arranged at 90° to each other.

6. A method as claimed in claim 4 or 5, wherein said jaws indent the ends of the bars to a depth of between 2(±1) to 4(±2)mm.

7. An apparatus for cold-working a workpiece, comprising a plurality of jaws arranged about a central axis to squeeze and indent a workpiece positioned on that axis, wherein the jaws comprise rotatable plates which have a portion arranged to indent the workpiece upon rotation of said plate.

8. An apparatus as claimed in claim 7, wherein the

indenting portions comprise teeth which are configured to form grooves in the workpiece.

9. An apparatus as claimed in claim 8, wherein the indenting portions are arranged to form longitudinal grooves in the workpiece.

10. An apparatus as claimed in claim 8 or 9, wherein the plates are mounted so that the plane of the plate includes the central axis along which the workpiece is to be positioned.

11. An apparatus as claimed in any of claims 7 to 10, wherein the apparatus is provided with four jaws spaced equally about the central axis.

12. An apparatus as claimed in any of claims 7 to 11, wherein the plates are approximately segment shaped and have a set of teeth provided on their outer circumferential surface.

13. An apparatus as claimed in claim 12, wherein the teeth of each plate engage a rack which is mounted to face the central axis and extend parallel to it.

14. An apparatus as claimed in claim 13, wherein an assembly holding the plates is movable along the central axis and relative to the racks, to rotate the plates and drive the indenting portions of the jaws simultaneously into the workpiece.

15. An apparatus as claimed in claim 14, wherein the assembly holding the plates is driven by a hydraulic piston.

16. A method of forming a thread on an end of a member comprising the steps of:

a) cold-forging the end of the member; and

b) forming a thread on said end of the member.

17. A method of connecting two metal bars using a threaded connector substantially as hereinbefore described with reference to the accompanying Figures 1 through to 5c.

18. An apparatus for cold-working a workpiece substantially as hereinbefore described with reference to Figures 3 through to 5c.

19. A squeezing plate substantially as hereinbefore described with reference to Figures 5a through to 5c.

20. A method of forming a thread on an end of a member substantially as hereinbefore described with reference to Figures 2.1 through to 2.5(b).

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Application No:	GB 9811161.0	Examiner:	Dave Butters
Claims searched:	1-6,16,17,20	Date of search:	10 August 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B3A, B3V, B3N

Int Cl (Ed.6): C21D

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	GB 0785534 A (WLODEK)(see figure 12i)	1,2,16
X	GB 0557960 A (NEWALL)	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.